INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: LCD CONTRAST ADJUSTMENT SYSTEM

(57) Abstract

A system for maintaining the contrast of an LCD at a constant level despite variations in temperature of the liquid crystal medium includes a temperature sensor and digital circuitry for generating a correction voltage that offsets the change in contrast level caused by the change in operating temperature.

* See back of page

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1

LCD CONTRAST ADJUSTMENT SYSTEM

BACKGROUND OF THE INVENTION

Modern technology has allowed the miniaturization
of computers to the extent that portable computers may be
used in the field to access, record, and process data.

A critical feature of any computer is the display
system. For a portable computer the length of battery life
is often critical and the use of a liquid crystal display
(LCD) allows the use of a small battery to achieve
reasonable battery life. However, LCDs have many drawbacks
in that visibility is often limited in extreme lighting
conditions and at certain viewing angles.

Additionally, the contrast of the liquid crystal
is dependent upon its temperature. At extremely low
temperatures the crystal tends to be opaque and at high
temperatures it tends to be highly transparent. Thus the
voltage levels required to create a readable display must be
adjusted to account for changes in temperature of the liquid
crystal medium.

Thermistor circuits to compensate for heat
generated internally by a computer are known. However,
portable computers designed for field use will encounter a
very wide range of operating temperatures from sub-freezing
to summer conditions in vehicles and buildings.
Compensation for such extremes is not possible with
thermistor circuits.

Thus, there is a great need to improve the
visibility of an LCD to provide portable computers having
low weight and long battery life.

SUMMARY OF THE INVENTION

The present invention is a system that
automatically compensates for variations in the contrast of
LCD due to changes of the temperature of the liquid crystal

2

medium due to large variations in the operating temperature
of the device utilizing the liquid crystal display.

According to one aspect of the invention, digital
data indicating the magnitude of the liquid crystal
temperature is processed to determine a contrast correction
factor required to maintain the contrast of the LCD at a
constant value. This factor is utilized to adjust the
contrast of the LCD to compensate for the effects of
temperature variation.

This compensation is transparent to the user and
provides a display that is maintains a constant desired
contrast level despite large changes in operating
temperature.

According to a further aspect of the invention, a
temperature sensor is coupled to a thermally insulating
material enclosing the liquid crystal medium to provide an
indication of the temperature of the liquid crystal.

Other features and advantages will become apparent
in view of the attached drawings and following detailed
description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a portable hand-
held computer having an LCD display;

Fig. 2 is block diagram of a preferred embodiment
of the invention;

Fig. 3 is a flow chart illustrating the operation
of the embodiment of Fig. 2; and

Figs. 4-6 are schematic diagrams depicting various
configurations for coupling a thermal sensor to the LCD.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A perspective view of a hand-held computer 10
including an LCD 12 is depicted in Fig. 1. It is intended
that the computer be suitable for use in the field where the
operating temperature may vary significantly when, for

3

example, the user goes from a heated room to the outdoors in winter.

Fig. 2 is a block diagram of an embodiment of the invention. A temperature sensor 20 outputs an analog sensing signal having a magnitude that varies as a known function of the temperature of the liquid crystal medium. As described below, the sensing device 20 must be thermally coupled to the liquid crystal screen in such a way that the thermal response nearly matches the temperature of the liquid crystal medium.

This analog sensing signal is converted to a digital sensing signal by an analog to digital convertor (ADC) 21 which is periodically sampled an stored in an SRegister 22. The SRegister output is coupled to the data input of a CPU 24 by a DBUS 26. The input of a CRegister 28 is coupled to the CPU 24 by the DBUS 26. The output of the CRegister 28 is coupled to the input of a digital to analog convertor (DAC) 30. Additionally, a system memory 31 is coupled to the CPU 24 by the DBUS 26.

The LCD 12 is represented by a capacitor 32. The upper plate of the capacitor is coupled to a voltage adder 34 having as its inputs the output to the DAC 30 and variable power supply 34. The variable power supply 34 allows a user to adjust the contrast of the LCD 12 to a desired level.

Fig. 3 is flow chart illustrating the steps of a temperature compensation program stored in the system memory 31. The operation of the system of Fig. 2 will now be described with reference to Figs. 2 and 3.

The contrast of the LCD 12 depends on the voltage difference impressed to the plates of the capacitor 32 and the magnitude of the temperature of the temperature of the liquid crystal medium in the LCD 12. The dependence of the contrast of a particular LCD on temperature and the magnitudes of the correction voltage required to correct this dependence is determined empirically and expressed in the form of either as a mathematical function or a table of

4

stored values. The program utilizes the value of the digital sensing signal read from the SRegister 22 to generate the digital correction signal. If a mathematical function is utilized the value of the digital correction signal is calculated utilizing the ALU of the CPU. If a table is utilized the CPU utilizes the digital sensing signal as an address to access the digital correction signal from a look up table stored in the system memory 31.

After the value of the digital correction signal is determined, the signal is transferred to the CRegister 28. This digital correction signal is then converted to an analog correction voltage signal by the DAC 30 and added to the variable power supply voltage by the voltage adder 34.

Figs. 4, 5, and 6 depict configurations for thermally coupling the sensor 20 so that its thermal response nearly matches the temperature of the LCD panel 12.

Referring to Fig. 4, the LCD panel 12 includes front and back glass plates 40a and b enclosing the liquid crystal medium 42. Two sensors 20a and b may be coupled to the different plates 40a and b to compensate for the thermally insulating property of the glass. Due to heat generated by operating the computer, the computer side of the display 12 is nearly always warmer than the outside air. By using two sensors 20a and b and averaging the an output closely matching the temperature of the liquid crystal medium 42 is obtained. If the thermal properties of the two plates are different a weighted average may be calculated to compensate for the difference.

In Fig. 5 the a single sensor 20 may be thermally coupled to plates 40a and b by a heat conductive element 50 thermally coupled to the plates 40a and b and the sensor 20. The heat conductive element 50 may be designed to compensate for variations in the thermal properties of the plates 40a and b to obtain an accurate representation of the liquid crystal temperature.

In Fig. 6 a thick, thermally insulating touch screen overlay 60 separates the upper plate 40a from the

5

outside temperature. Thus, the temperature of the liquid
crystal medium 42 is closely approximated by the temperature
of the lower plate 40b. A single sensor 20 is thermally
coupled to the lower plate 20b and insulated from the
5   temperature inside the computer by an RTV-1 like material of
a thickness having a thermal length that approximates the
property of the lower plate 20b. Alternatively, the sensor
may measure the inside temperature of the computer as a
rough approximation of the temperature of the liquid crystal
10   medium 42.

              The user adjusts the variable power supply to
achieve the initial desired contrast. The temperature
correction system then provides the required voltage to
offset changes in contrast due to temperature variations so
15   that the contrast level of the display remains as set by the
user.

              The invention has now been described with
reference to a preferred embodiment. Variations and
substitutions will now be apparent to persons of ordinary
20   skill in the art. Accordingly, it is not intended that the
invention be limited except as provided by the appended
claims.

6

WHAT IS CLAIMED IS:

1. A system for maintaining the contrast of an LCD including a liquid crystal medium, having a contrast dependent on its temperature, at a constant level despite changes over a large range of operating temperature, said system comprising:

means for indicating the magnitude of the temperature of the liquid crystal medium;

means, responsive to said indication, for generating a digital contrast correction signal dependent on said magnitude; and

means, responsive to said digital contrast correction signal, for adjusting the contrast of LCD to compensate for level changes due to variations in ambient temperature.

2. The system of claim 1 wherein said liquid crystal medium is enclosed in first and second plates and wherein said means for indicating further comprises:

first and second thermal sensors thermally coupled to respective ones of the first and second plates;

means for averaging the output of said sensors to compensate for different thermal properties of said plates.

3. The system of claim 1 wherein said liquid crystal medium is enclosed in first and second plates, the first plate being insulated from the outside temperature by a thick touch screen and the second plate adjacent to the inside of a computer and wherein said means for indicating further comprises:

a sensor thermally coupled to said second plate;

means for insulating said sensor from the inside temperature of the computer.
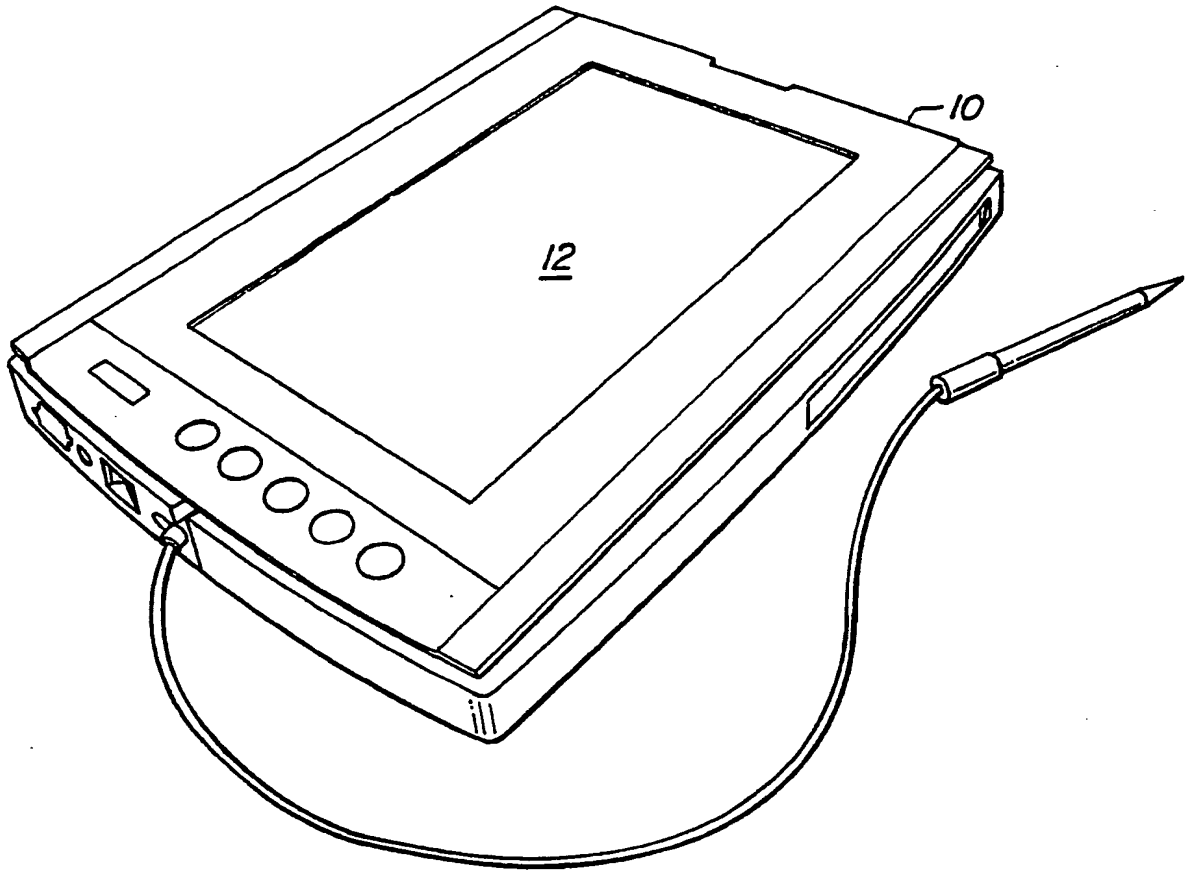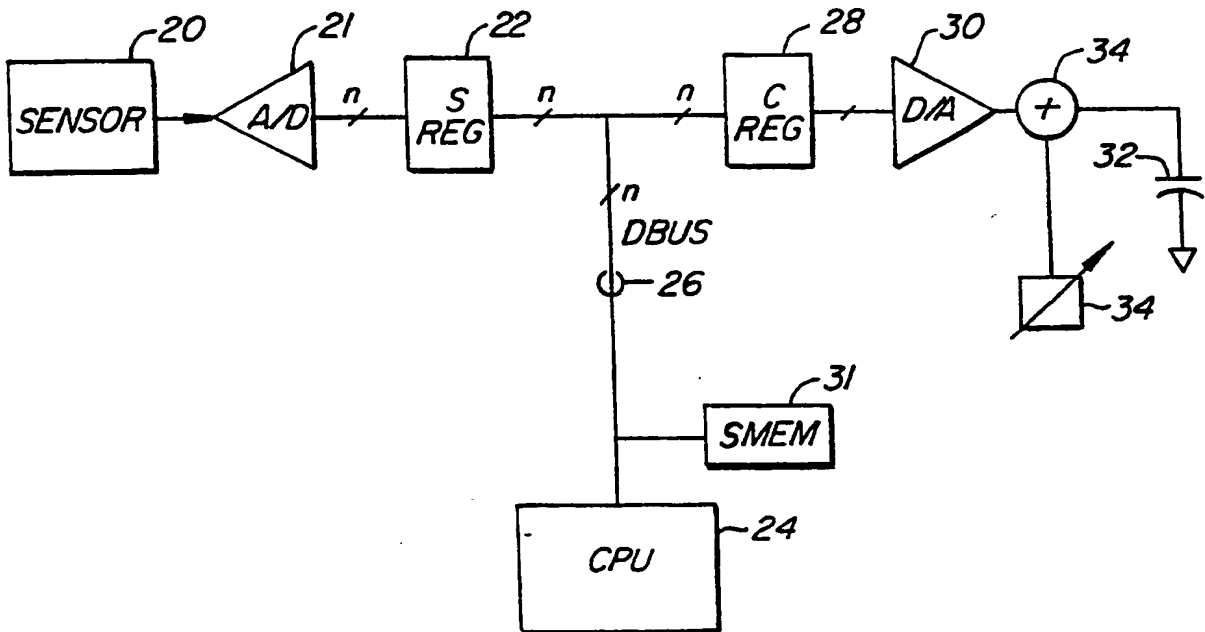
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FIG.—1.

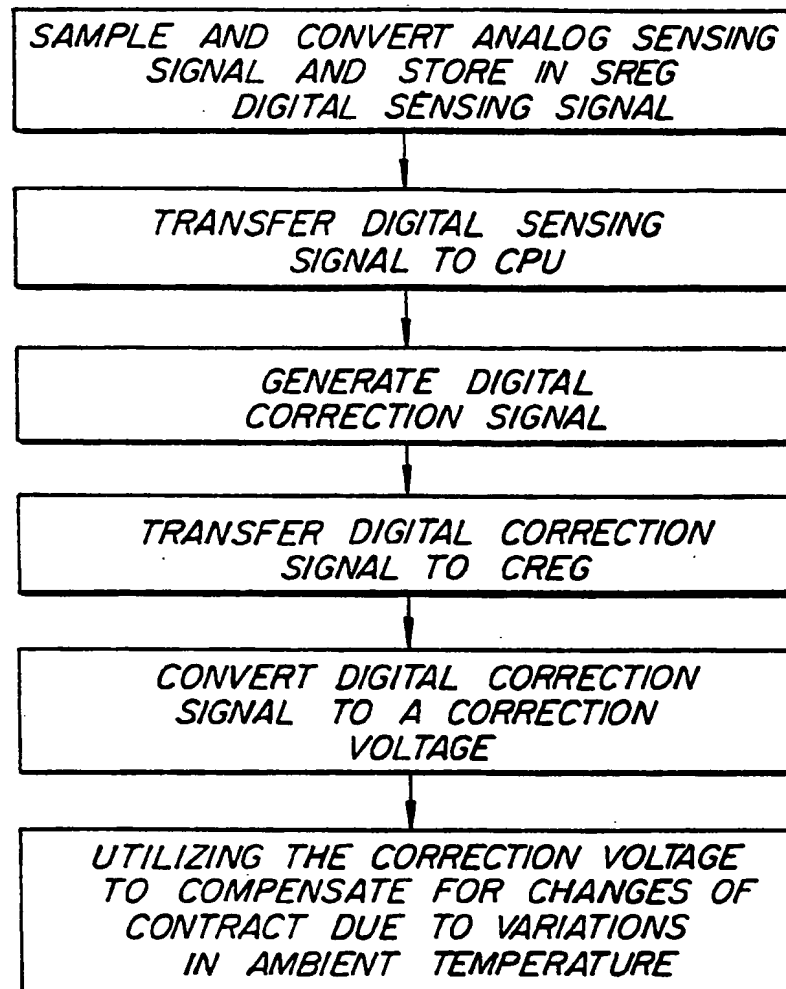*FIG.—2.*

2/4

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┌─────────────────────────────────────────┐
│   SAMPLE AND CONVERT ANALOG SENSING      │
│   SIGNAL AND STORE IN SREG               │
│       DIGITAL SENSING SIGNAL             │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│     TRANSFER DIGITAL SENSING             │
│          SIGNAL TO CPU                    │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│        GENERATE DIGITAL                   │
│       CORRECTION SIGNAL                   │
└─────────────────────────────────────────┘
                    │
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┌─────────────────────────────────────────┐
│    TRANSFER DIGITAL CORRECTION           │
│         SIGNAL TO CREG                    │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│    CONVERT DIGITAL CORRECTION            │
│     SIGNAL TO A CORRECTION               │
│              VOLTAGE                      │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│  UTILIZING THE CORRECTION VOLTAGE        │
│  TO COMPENSATE FOR CHANGES OF            │
│  CONTRACT DUE TO VARIATIONS              │
│     IN AMBIENT TEMPERATURE               │
└─────────────────────────────────────────┘
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FIG._3.
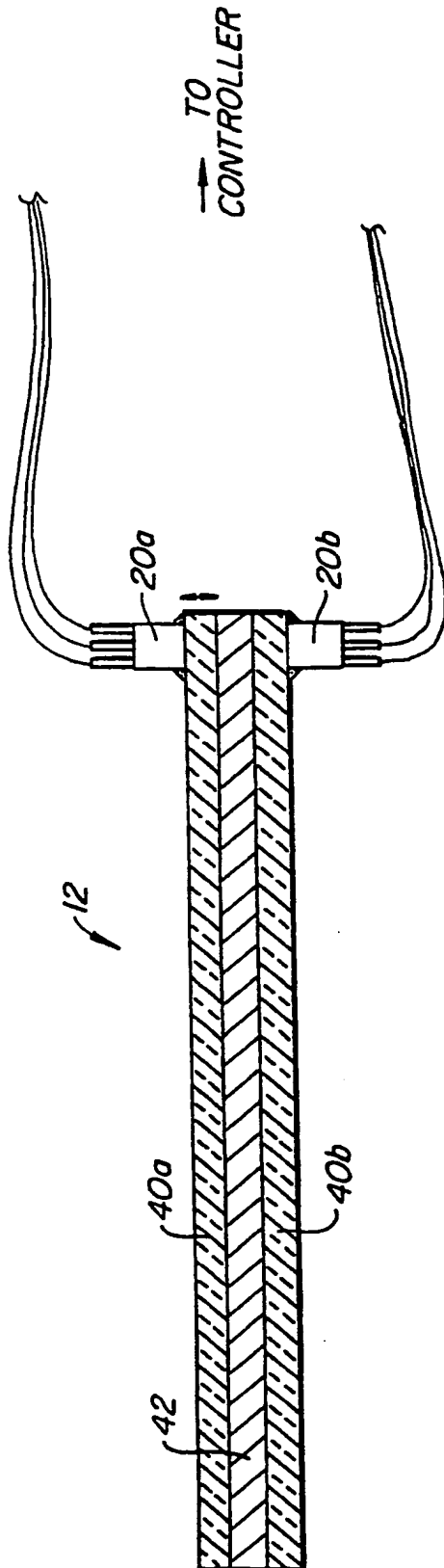
FIG._4.
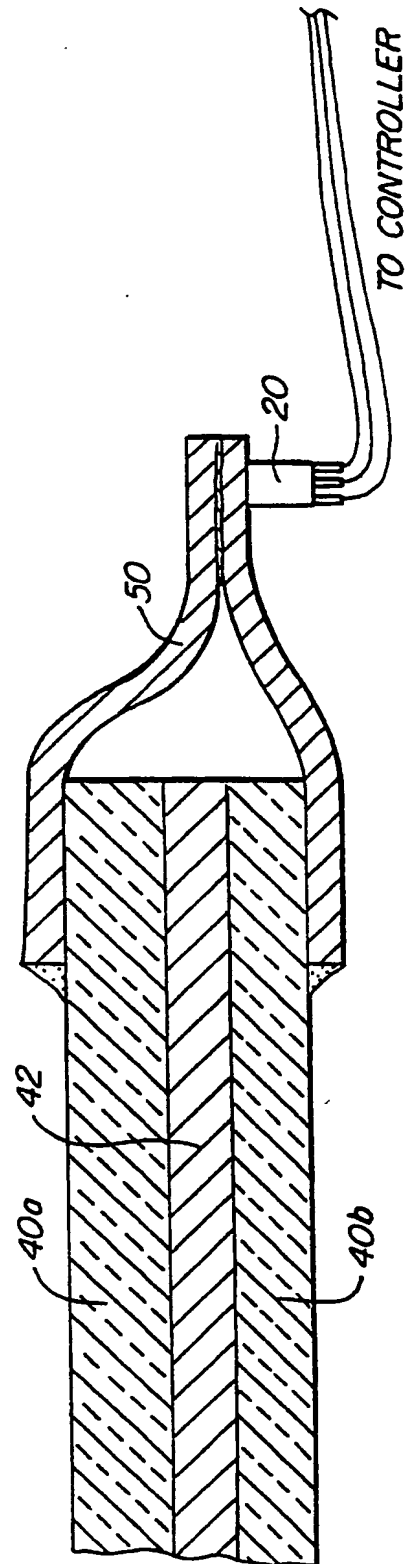

FIG._5.
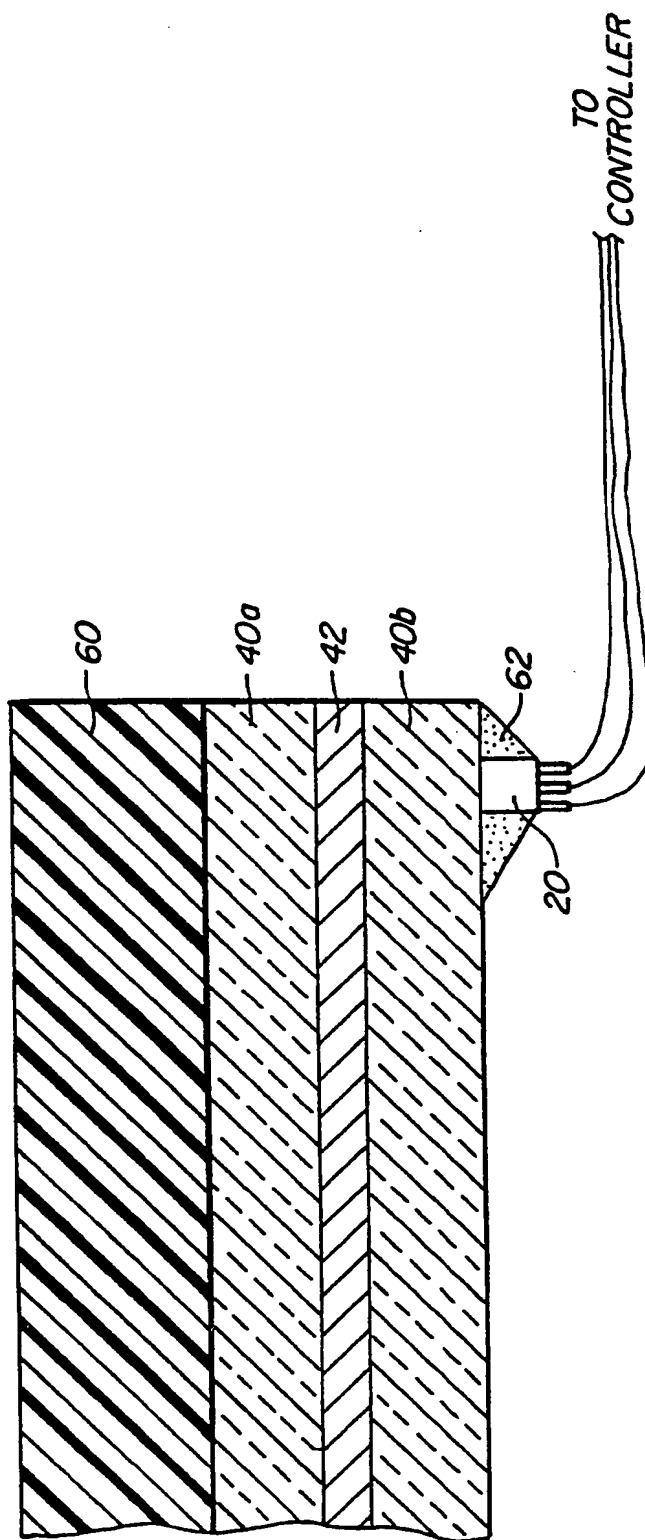
4/4

60
40a
42
40b
62
20

TO
CONTROLLER

FIG._6.

INTERNATIONAL SEARCH REPORT

International Application No   PCT/US90/05063

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5):   G02F 1/13   G09G 1/06
US CL.: 350/33IT, 331R, 334, 336   340/713

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System ·	Classification Symbols
US	350/33IT, 331R, 334, 336 340/713

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X,P	US, A, 4,917,469 ROSS 17 APRIL 1990 See the entire document	1-3
X,P	US, A, 4,923,285 OGINO ET AL. 08 MAY 1990 See the entire document	1-3
Y	US, A, 4,723,836 KONO ET AL. 09 FEBRUARY 1988 See the entire document	1-3
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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [3]
16 OCTOBER 1990	31 JAN 1991
International Searching Authority [1] ISA/US	Signature of Authorized Officer [20] HUY K. MAI

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